THE CONTINUING REHABILITATION OF THE KAM KOTIA MINE SITE: AN ACID-GENERATING ABANDONED TAILINGS SITE

Christopher D. Hamblin[1]

Abstract: Ontario's Ministry of Northern Development and Mines (MNDM) continues to rehabilitate the Kam Kotia Mine site. This site, located within the municipality of Timmins, in northeastern Ontario, Canada, is considered by many to be one of the worst abandoned mine sites in Canada.

The Kam Kotia mine originally produced base metals in the early 1940's, with production ending in 1972. During that time 6.0 million tonnes of highly sulphide-rich tailings were deposited into three areas, two of which were unimpounded. The mine site is located on approximately 500 hectares of land and has produced acid mine drainage and metal leachate that has severely impacted sections of two rivers and caused concern for ground water in the area.

A conceptual rehabilitation plan was developed in the year 2000, with each of the five phases being of a distinct and unique benefit. The plan was formulated so that if funding was discontinued before all rehabilitation had been completed, the improvements achieved to that point would not be lost. However, it is now expected that sufficient funding will be available to complete the full rehabilitation of the site by 2009.

Currently MNDM has completed the first three phases, and much of the final phase of the rehabilitation plan. However, the much greater than expected volume of contaminated water that collected on the site resulted in operational problems in the implementation of the conceptual plan, causing a substantial cost increase.

To date, MNDM has expended almost CA$49 million on the rehabilitation of the site, and it is now estimated that the total rehabilitation costs will be greater than CA$55 million. This total cost does not include the operation of the on-site water treatment plant, which will need to operate until all south flowing acidic water has been treated or flushed from the site. It is expected this treatment will take approximately fifty years.

Key Words: abandoned mine, rehabilitation, reclamation, acid mine drainage, metal leachate, AMD, ARD.

Introduction

The Kam Kotia Mine site is located in Robb Township in the northwest corner of the City of Timmins, Ontario, Canada. The mine produced copper, zinc and secondary silver and gold, and was originally developed in the 1940's under the Federal Government's War Minerals program. Subsequent to the ending of that program, the mine was operated by a commercial operator intermittently, finally ceasing operations in 1972. Since then, the mining and surface rights of most of the site have reverted to the Provincial Crown, leaving the responsibility of rehabilitation in the public realm.

[1] Christopher D. Hamblin, Project Coordinator, Abandoned Mines Rehabilitation Program, Ministry of Northern Development and Mines, Sudbury, ON, P3E 6B5

While there are a number of physical hazards located on the site, the primary mine rehabilitation concern was the 6 million tonnes of high sulphide tailings on the site, located mainly within three distinct tailings areas. For the most part, the tailings were released without any impoundment and ultimately covered an area of approximately 500 hectares. Acid mine drainage (AMD) and metal leachate (ML) has been produced from all three of the tailings areas, and has had a great impact on the receiving lands and waters. In addition, there have also been issues with dusting, aesthetics and the physical mine hazards, such as the main shaft, an open pit and a thin crown pillar.

The three main tailings areas located on the Kam Kotia Mine site are shown in the Figure 1 site plan below and are referred to as follows:

a) the "North Unimpounded Tailings" or "NUT" located in the northeast area of the site,

b) the "North Impounded Tailings" or "NIT" located in the northwest area of the site, and

c) the "South Unimpounded Tailings" or "SUT" located in the southern area of the site.

Fig. 1: An aerial view of the Kam Kotia Mine site prior to the commencement of rehabilitation.

For many years the area to the south of the mine site was known as the "south kill zone", and was an area in which virtually all vegetation had been destroyed by the site's contaminated discharge. Acidic drainage from the SUT area flowed southwards into the Little Kamiskotia River and resulted in the severe impacts on that river, with its waters at a pH of 3 or lower.

The areas to the north and northeast have been similarly impacted by contaminated drainage from the NUT area, and the Kamiskotia River to the north of the mine site has been almost as heavily affected as the Little Kamiskotia River. (See Figure 2 for a view of the NUT area and one of the acidic seeps.)

Fig. 2: A view of the NUT area, and the northeast seep with a pH of 2 to 3, prior to rehabilitation.

In response to rising concern over impacts to the local environment from the contaminated drainage from the site, and the possibility of the contamination of groundwater in the area, MNDM contracted a consortium of firms in the year 2000. This consortium, headed by SENES Consultants Limited, developed a plan to rehabilitate each of the environmental and health and safety hazards on the site. MNDM continues to use that plan currently in its ongoing rehabilitation work on the site.

This paper follows an earlier one that the author presented at the Sudbury: Mining and Environment 2003 Conference. However, details are now available on both the successes and difficulties that have occurred during the rehabilitation efforts that have been undertaken since that time.

The Five Phases of Rehabilitation

After considering various options to rehabilitate the site, SENES developed a five-phased approach for the rehabilitation of the Kam Kotia Mine site. These are referred to as Phases "A" to "E". Each phase was to be of a distinct and unique improvement to the site and each was expected to take up to one year to conduct. (See Figure 3 for a site plan showing the five phases of rehabilitation for the site.) The SENES plan predicted that the total cost to completely rehabilitate the site, including 50 years of operating the lime plant, would total approximately $41 million. However, based on the work that the Ministry has completed to date, it is now expected that the total cost to rehabilitate the site will be much higher.

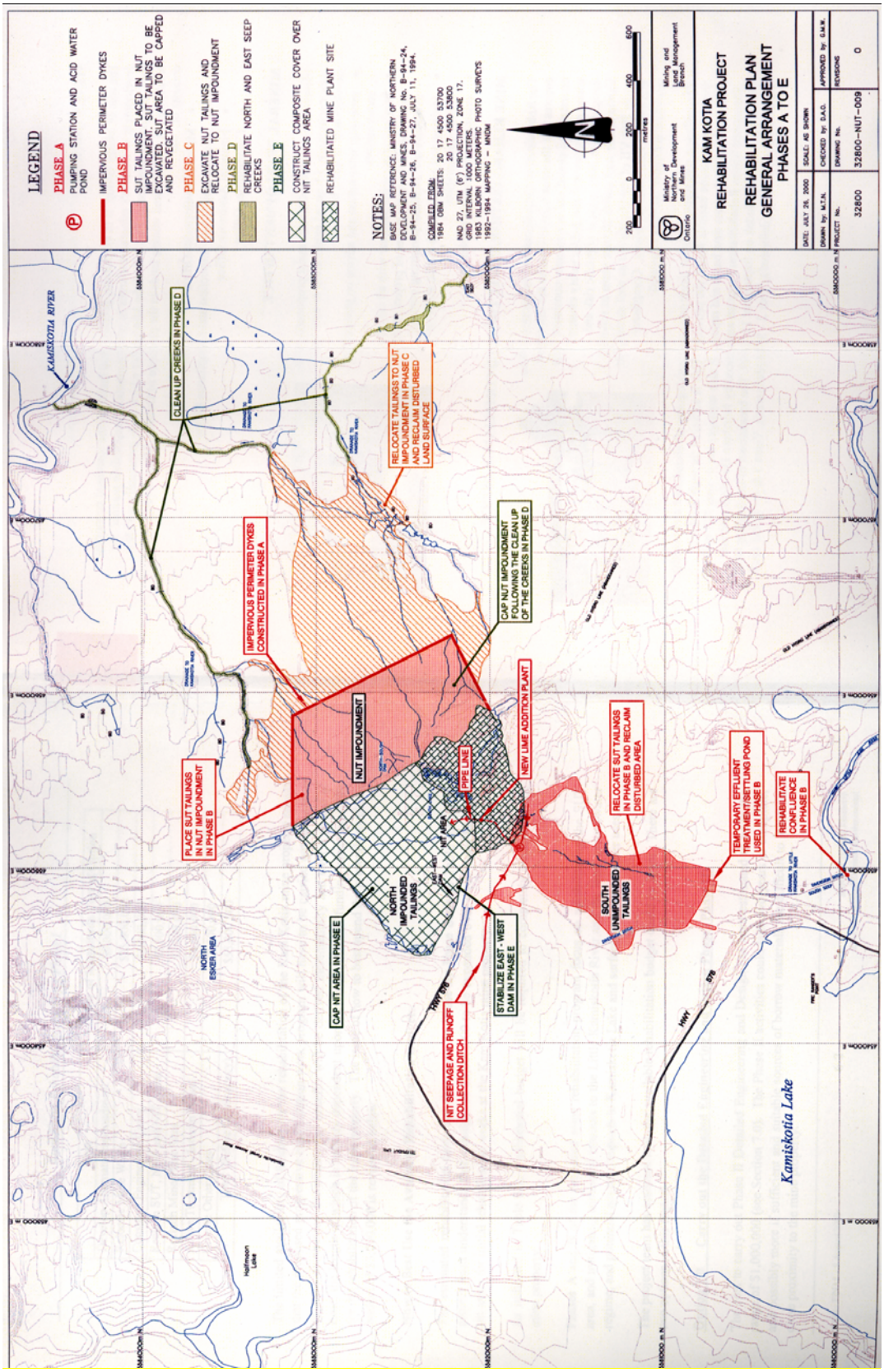

Fig. 3: A map of Kam Kotia showing the five phases of rehabilitation (SENES, 2000)

The five-phases of SENES' conceptual plan were as follows:

Phase "A" would actually consist of two separate projects. The first would be the construction of a high-density sludge lime addition treatment plant, and its intercept ditch and other required infrastructure. The other project would be the construction of an earthen impoundment dam structure within the NUT area.

Phase "B" would deal with the relocation of the SUT tailings to within the newly constructed NUT impoundment area, where they were mixed with lime and neutralized.

Phase "C" would be similar to Phase "B", but would involve the relocation of the larger volume of unimpounded NUT tailings remaining outside of the new NUT impoundment dam, to within that NUT impoundment area.

Phase "D" was another two project phase, the first of which will involve the collection of tailings from the north and east creeks, and the other which would involve the construction of a "moist" cover over the NUT impoundment area after all previously unimpounded tailings SUT and NUT area have been relocated to within the impoundment area. This cover is to consist of a thick sand layer that will be kept saturated so that no further AMD and ML can be produced from the tailings underneath.

Phase "E" would also consist of two projects. The primary Phase "E" project would involve the construction of an engineered, multi-layer "dry" cover over the NIT area tailings. However, Phase "E" is also to deal with the rehabilitation of all of the physical hazards on the site, such as the open pit, recapping the main shaft, and dealing with the thin crown pillar and all of the foundations remaining on the site.

Post-Phase "E" work will consist of a general clean-up of the site and the long-term operation of the lime plant. The Senes plan predicts that, once all five phases of site rehabilitation are complete, and no further AMD and ML are being produced, the lime plant will need to operate for at least three groundwater flushings. It is predicted that these three flushings will take approximately fifty years, and will completely remove all existing contaminants from the site. However, it is also predicted that the lime plant will have to run forever if the entire five-phased rehabilitation plan is not fully completed.

The Work Undertaken To Date – Successes and Complications

Phase "A"

Phase "A", the first true rehabilitation work conducted on the site, was begun once an engineering design had been prepared for Phases "A" and "B". The Phase "A" work started in the fall of 2001 and ended by mid-summer of 2002.

The lime plant was constructed on the old mine plant area, and has now operated for more than five years. Various problems were encountered with the lime plant, both during construction and later during its operation. One of the major problems involved the selection of pumps. The engineering design had initially indicated that using cast iron pumps would be more cost effective than stainless steel, even with a shorter replacement frequency. However, the first set of impellors were completely eaten away in less than six weeks and it soon became apparent that all of the pumps would have to be changed to the much more expensive stainless steel.

During the construction of the plant, changes also had to be made to the sludge outfall piping resulting in costs for this component escalating to about three times that originally bid. To cover these additional

costs, some of the tailings north of the SUT interception ditch were left in place, to be removed during the Phase "B" work. The lime plant was completed on March 30, 2002 with no cost overruns.

The current operator of the lime plant continues to make efficiency modifications and the plant now operates more efficiently than it ever has before.

The construction of the NUT impoundment dam was the second Phase "A" project. This newly impounded area was designed to hold all of the remaining unimpounded tailings, which were to be physically relocated to within the dam area during the subsequent phases of rehabilitation, neutralized with lime and then covered so that the impounded area can be developed as a wetland. While the construction was completed successfully, a number of problems were encountered.

One of these problems involved the existing "North-South" dam. In addition to the work specified by the SENES plan, the engineering design determined that substantial additional stabilization and reinforcement of the existing "North-South" dam would have to be undertaken, at approximately $1.2 million in additional cost. Then during the construction the contractor had difficulty developing the granular and clay pits due to warmer than usual winter weather, so the project completion date was extended until the summer of 2002.

Once the construction of the dam started, it was realized that the information provided during the tender was not adequate and that approximately $400,000 was required for the extra material in the NUT dam due to lower than expected original ground. Since there was no cost overrun allowed, it was decided to forego the topsoil and seeding of the NUT and the North-South dam to offset the extra costs. The dam construction project was completed by July 18, 2003 with no cost overruns.

SENES had predicted that the Phase "A" work would cost approximately $4.8 million, including a 30% contingency allowance. This cost estimate was increased to more than $7 million after the detailed engineering had been completed and it was realized that the existing north-south dam would require substantial upgrading. However, the actual bid prices for the two Phase "A" construction projects totaled $9.85 million.

Phase "B"

Phase "B" was undertaken during the winter of 2002/03 and dealt with the relocation of the SUT tailings to within the newly constructed NUT impoundment area, where they were mixed with lime and neutralized. The predicted volume of tailings to be relocated was 330,000 m^3, at an expected cost of $3.3 million. However, there were actually more than 340,000 m^3 of SUT tailings relocated, at a total cost of $3.4 million.

A cost saving of almost $1 million was achieved during Phase "B" by using a product called "Envirolime" to neutralize the relocated tailings, rather than the more commonly used hydrated lime. Although a slightly greater amount of the Envirolime was required to get the same results as the hydrated lime, the cost for the Envirolime per unit volume was less than half of that of hydrated lime. The Envirolime was also an easier product to apply to the relocated tailings than hydrated lime as it can be applied in a dry state and doesn't tend to be as windblown due to its coarser granular form. The constituents of Envirolime are: CaO – 63 to 75%, MgO – 1 to 8%, and SiO_2 – 1 to 2%.

The Phase "B" work started slowly due to both heavy snow and milder than usual temperatures in the early part of the winter, which contributed to very poor frost conditions. As a result, excavation and transport of the first loads of tailings did not occur until the second week of January, and much of the early work was sporadic. Fortunately, a period of very cold temperatures started in mid-January and

lasted right through February and the contractor was able to greatly increase its production rate by operating 24/7 with substantially more equipment than originally planned.

In order to reduce the total project costs to below the price cap that had been placed on the Phase "A" and "B" work, it was decided that the revegetation of the SUT area would not be conducted. However, Ag Lime was still spread over the peat/soil surface after the removal of the tailings to provide increased buffering capacity in the pore water in the ground, and the area has begun to revegetate naturally.

The completion of the Phase "A" and "B" work meant that, other than the contaminated pore water in the area from before the SUT tailings were removed, there would be very little, if any, further new effluent discharged to the areas to the south and southwest of the mine site – the areas where there is human habitation.

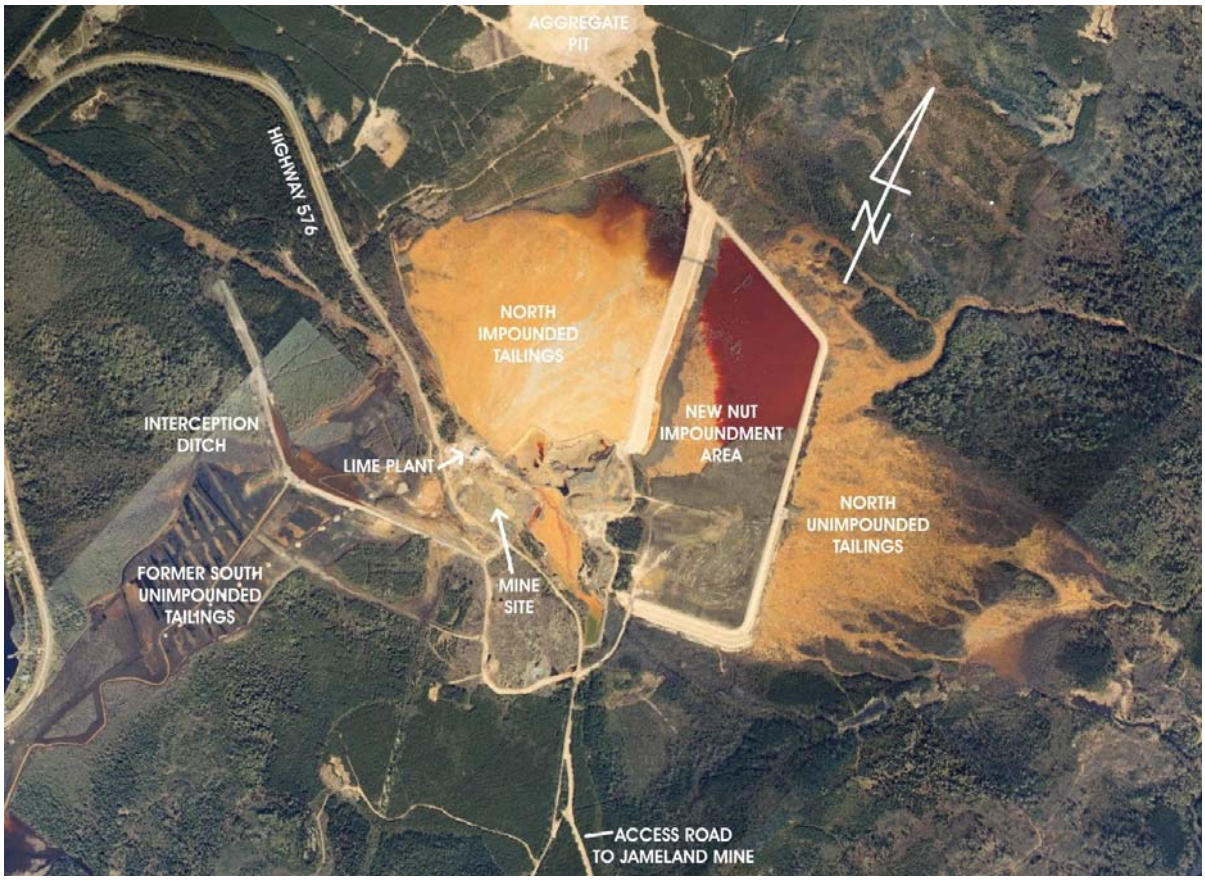

Fig. 4: Aerial view of the Kam Kotia Mine site after the completion of Phases "A" and "B" (May 2003).

Phase "C"

The Phase "C' work was conducted during the winter of 2003/04. The plan had been to relocate the unimpounded NUT tailings that remained outside of the new NUT impoundment dam to within the NUT impoundment area. The estimated volume of tailings to be removed was 750,000 m^3, so the expected cost made it necessary to plan for this work to be conducted over two fiscal years. However, before the work could begin the first major complication of the Kam Kotia rehabilitation had to be solved.

The summers of 2002 and 2003 each saw extremely higher than normal precipitation. The SENES plan had predicted that contaminated water would collect in the NUT impoundment area, but that this water

was to be treated and pumped over to the higher elevation NIT area. However, with the much greater than expected volume of contaminated water that collected this was not possible and the NUT impoundment area began to fill with contaminated water that could not be discharged to the environment without undergoing treatment first. The initial collection of this water (aka "the pond") can be seen in the northeast corner of the NUT impoundment area of Figure 4, and then throughout the NUT impoundment area in Figure 5.

Since placing the Phase "C" tailings in the proper location would result in the discharge of the contaminated pond water out the dam's spillway, MNDM had the choice of either postponing or cancelling the Phase "C" contract, or to find some other way to conduct the project. It was decided that the tailings would be stacked along the west and south sides of the pond so that the work could proceed without causing any displacement of the contaminated pond water. (Please see Figure 5.)

Fig. 5: Aerial view of the Kam Kotia Mine site after the completion of Phase "C" (May 2004).

MNDM had planned to relocate about 500,000 m^3 of tailings during the first Phase "C" contract, with the removal of the remaining NUT area tailings awarded the following winter in a second contract, along with the Phase "D" removal of the tailings from the north and east creeks. However, it became apparent as the first contract neared its end that there were substantially less tailings in the NUT area than had been expected. MNDM managed to budget additional money for the project and the contactor actually relocated slightly more than 611,000 m^3, leaving only about 5,000 m^3 that they were unable to retrieve due to losing the ground frost as a result of the spring thaw. This small amount of NUT tailings is expected to be removed during the winter of 2007/08 when all remaining unimpounded tailings are also relocated to within the NUT impoundment.

The Phase "C" work ultimately cost $6.91 million. However, this cost does not include the subsequent cost to relocate the stacked tailings to their proper location within the NUT impoundment area.

The In-situ Treatment of the Contaminated "Pond" Water

During the winter of 2003/04, and simultaneously with the Phase "C" project, MNDM contracted with the operator of the lime plant to neutralize and discharge the contaminated pond water. The Ministry of Environment (MOE) had provided MNDM with discharge criteria and the lime plant operator believed that they would be able to successfully treat and discharge the pond in-situ, as they had previously done for a similar situation in Elliot Lake, Ontario. The initial commitment was for MNDM to pay up to $250,000 to treat the pond, so the contractor began the treatment with dry lime. When that was not successful, presumably due to mixing problems in the sub-zero temperatures, the contractor began to add heated lime slurry.

After the addition of 706 tonnes of lime being added to the pond, with very little change to the pH, acidity or metal levels, it was determined that the caustic (NaOH) would be used instead of lime. There were concerns that the pond could become to alkaline to discharge with only a couple of tanker-loads of caustic being added.

The caustic did begin to slowly raise the pH levels, and subsequently lower the acidity and metals levels, although no where near as quickly as expected. At one point the contractor actually began to discharge treated water, but this could only be conducted for three hours until the water quality dropped again below MOE's discharge cut-off levels. In the end, more than 200 tanker loads of caustic, containing more than 2,000 dry tonnes of caustic had been unsuccessfully added to the pond. The total cost for the in-situ treatment was $1.8 million.

The Vegetation of the NUT Impoundment Dams

The seeding of the NUT area impoundment dams had been removed from the Phase "A" work as a cost saving. However, over time it was realized that the dams were being badly eroded by both wind and water. Therefore, a project was contracted for the vegetating of the dam surfaces.

The project was conducted during the fall of 2003, at a cost of $276,000. This cost was shared equally by MNDM and the Ontario Mining Association (OMA) as the first project conducted under a partnership agreement for various abandoned mine rehabilitation projects within Ontario.

Phase "E" - The Construction of the Initial Layers of the NIT Area "Dry" Cover

In order not to delay the continuation of the rehabilitation of the Kam Kotia Mine site, and since the Phase "D" NUT cover work could not be completed until the contaminated pond water was gone, MNDM decided to conduct the construction of the initial two layers of the NIT area "dry" engineered cover, which is part of the Phase "E" work.

An engineering consultant was contracted to provide an engineering design for this cover during the summer of 2004. The engineers determined that there were freeze-thaw concerns with the local clay that might result in frost lensing over a 10 to 25 year period, so a complete design for the barrier layer for this cover could not be provided until further tests were undertaken. However, regardless of the eventual design of the upper layers, it was known that the lower-most layers of the cover would be a capillary break to stop acidic water wicking upwards and attacking the barrier layer.

This capillary break was determined to consist of an initial 300 mm. thick layer of minus-6 inch crushed rock covered by a 300 mm. thick layer of granular-B material. The engineer indicated that this capillary break would need to be constructed with frost in the ground so that the construction equipment would not become mired in the soft tailings. Then the design called for the subsequent layers of the dry cover to be constructed during non-freezing conditions, with the capillary break layers being a suitable base to support the construction equipment required for that work.

The construction of the Phase "E" NIT cover capillary break was successfully completed during the winter of 2004/05, at a cost of $3.4 million. In addition to using the granular B material available in an MNDM licensed pit on site, the required minus-6 inch rock layer was produced by crushing and hauling a large stockpile of acid generating waste rock located on the site, thereby turning a previous environmental liability into a valuable construction material.

The Treatment of the Contaminated Pond Water Using a Temporary Treatment Plant

After the in-situ treatment did not work, MNDM hired a consultant during the summer of 2004 to determine all different options of how the contaminated pond water could be treated and then to recommend a preferred option. The consultant determined that it would be better to batch treat the contaminated water using a large temporary treatment plant. The water would be neutralized with caustic, and would then be pumped into one of a series of geotextile filter bags until the sludge settled out and the clean, treated water filtered through so that it could be discharged. See Figure 6 for an aerial view of these geotextile bags, which are also visible on the Google Earth™ image of the Kam Kotia site at the time of writing this paper.

This paper is not going to go into any detail regarding the process used for this temporary treatment plant as B. Dowsley is preparing a paper and presentation on this subject for the Sudbury Mining and Environment 2007 conference. In short, a contractor was hired during the summer of 2005 to build the temporary treatment plant, treat and discharge the water, and then relocate the stacked NUT area tailings to their proper location within the NUT impoundment area.

This project was completed successfully before the end of March 2006, at an eventual cost of $9.383 million. Several problems were encountered, and successfully dealt with during the execution of the project, including:

- the summer of 2005 was extremely hot and dry, so the pH dropped to lower than 2.5 and the acidity and metal levels in the pond water increased by three to five times the concentration at the time of award of the contract,
- the sludge amounts produced increased from the original 30% content to more than 70%, which the contractor managed to partially deal with by modifying the flocculent type and application rate, and
- the 500 micron mesh in the geotextile bags would "blind" or clog up much faster than expected due to the increased sludge amounts.

Fig. 6: Aerial view of the Kam Kotia Mine site after the construction of the NIT cover capillary break layers and the installation of the NUT area temporary water treatment plant near the southeast corner of the NUT impoundment dam (Hazco - June, 2005).

Fig. 7: The geotextile filter bags used for the temporary treatment of the contaminated pond water.

Phase "E" - The Construction of the Remaining Layers of the NIT Area "Dry" Cover

The engineer preparing the design of the NIT area "dry" cover eventually determined that the local clay would not sufficiently last. So instead, the design called for the use of a geosynthetic clay liner (GCL) to form the barrier layer of the cover. This cover was designed as follows: (NOTE: the layers are listed in the order that they are to be installed, and not in the order that they would appear in cross-section.)

Table 1: GCL specifications

GEOTEXTILE PROPERTIES	TEST METHOD	MINIMUM TEST FREQUENCY	VALUE
Cap Non-woven Mass/Unit Area	ASTM D 5261	1/20,000 sq. m	200 g / m^2 MARV
Woven Scrim Mass/Unit Area *Polypropylene membrane applied to the woven fabric*	ASTM D 5261	1/20,000 sq. m	105 g / m^2 MARV
BENTONITE PROPERTIES			
Swell Index	ASTM D 5890	1/50,000 kg	24 ml / 2g min.
Moisture Content	ASTM D 4643	1/50,000 kg	12 % max.
Fluid Loss	ASTM D 5891	1/50,000 kg	18 ml max.
FINISHED GCL PROPERTIES			
Bentonite Mass Per Unit Area[1,2]	ASTM D 5993	1/4,000 m^2	3.66 kg / m^2 MARV
Grab Strength[3]	ASTM D 4632	1/4,000 m^2	422 N MARV
Grab Elongation[3]	ASTM D 4632	1/4,000 m^2	150 % Typical
Peel Strength[4]	ASTM D 4632	1/4,000 m^2	66 N
Permeability[5]	ASTM D 5084	1/10,000 m^2	5×10^{-10} cm/sec max 5×10^{-13} cm/sec E96
Index Flux[5]	ASTM D 5887	1/Week	5×10^{-9} m^3/m^2/sec
Internal Shear Strength[6]	ASTM D 6243	Periodic	24 kPa
DIMENSIONS			
Width x Length	nominal	Every Roll	4.7 x 45.72 m
Area per Roll	nominal	Every Roll	216 m^2
Packaged Weight	typical	Every Roll	980 kg

1. *Oven-dried measurement. Equates to 0.84 lbs when indexed to a 12% moisture content.*
2. *Bentonite moisture content during manufacturing shall be no more than 12%.*
3. *Measured at maximum peak, in the weakest principal direction.*
4. *Modified to use a 4 inch wide grip. The maximum peak of five specimens averaged.*
5. *De-Aired Tap Water @ 5 psi maximum effective confining stress and 2 psi head. Side-wall leakage typical due to extremely low permeability. Specified value based on calculated value from ASTM E 96 testing.*
6. *Typical peak value for specimen hydrated for 24 hr. and sheared under a 200 psf normal stress.*

1. A GCL installed over the NIT area capillary break layer, after the surface of the capillary break was appropriately re-graded and prepared. See Table 1 for the GCL specifications required under the contract.
2. A 300 mm. layer of clay over the GCL. The clay available on-site was of sufficient quality and did not need to be compacted as it is only required to act to keep the GCL hydrated, and is not required to act as the cover's barrier layer.
3. A 500 mm. layer of granular fill (i.e. the granular-B material available on the site).
4. A 150 mm of "topsoil" *.
5. Revegetation of the "topsoil" layer of the cover by applying an appropriate shallow-rooted seed mix.

* There are not sufficient quantities of true topsoil available in the area for the required 150 mm. layer of the NIT cover. However MNDM is mainly concerned that the vegetation has a suitable medium for sustainable growth, so the contract for this project specifies that the contractor must warranty that there will be sustainable, shallow-rooted vegetative growth over the entire NIT area after a two-year period. It is up to the contractor to determine what they will use as "topsoil".

Fig. 7: Aerial view of the NIT area of the Kam Kotia Mine site during the construction of the remaining layers of the NIT cover. (Hazco - November, 2006).

Due to the great cost predicted, a two-year contract for the NIT cover completion work was awarded during the summer of 2006. The total upset-limit bid cost of the project was $12.3 million, which MNDM had intended to spread equally over fiscal 2006/07 and 2007/08. However, the contractor found that contrary to the engineer's predictions, frost conditions were still needed to ensure that the construction equipment did not break through the previously installed layers. So, the contractor elected to operate through the winter of 2006/07 and, at the time of writing, has completed all of the project work requirements except for the topsoil layer and seeding.

The project must be completed by March 31, 2008. However, at the time of writing it is expected that the work will be finished by the end of the summer or the beginning of fall of 2007.

Future Phases of Rehabilitation at Kam Kotia

Assuming that funds continue to be available, the remaining phases of rehabilitation at the Kam Kotia Mine site will be conducted. A description of each of these planned phases follows

The Collection of All Remaining Unimpounded Tailings on the Site

During the summer of 2004, MNDM contracted a consultant to locate and quantify the location of all remaining tailings on the site. It is now known that there are approximately 39,000 m^3 of unimpounded tailings remaining on the site. These tailings include:

- the estimated 5,000 m^3 of tailings not collected during Phase "C".
- the Phase "D" work, which calls for the removal of tailings from the north and east creeks. The east creek has completely revegetated and rehabilitated naturally, so removing any tailings in this area would actually worsen the creek's condition. However, there is an estimated 25,000 m^3 of tailings in the two branches of the north creek.
- an estimated 14,000 m^3 that have been recently discovered to the west of the SUT area, and were not previously known.

It is now planned that these tailings will be relocated to within the NUT impoundment area during the upcoming winter of 2007/08. Furthermore, MNDM and the OMA have agreed that this will be the next project conducted under their joint funding agreement, with the project costs being paid for equally by the two organizations

Phase "D": The Construction of the NUT Impoundment Area "Moist" Cover

It is planned that the Phase "D" moist cover will be constructed during the winter of 2008/09. The project will involve the placing of a sand/granular-B layer directly over the placed tailings in the NUT impoundment area. This layer will be approximately 600 mm. thick and will be kept in a saturated state by appropriately controlling the water table within the NUT impoundment area.

Once the constructed cover cuts off oxygen to the tailings, no further AMD and ML should be produced by the tailings below. Although it will take some time to flush the pre-existing contaminants from the area, the entire NUT impoundment area is expected to eventually become a wetland.

Phase "E": The Rehabilitation of Kam Kotia Physical Hazards

As stated previously, the final work required under Phase "E" will be the rehabilitation of the physical mine hazards on the site. This work will require a detailed engineering study and design, but in general the measures that are expected in this project are as follows:

- the open pit – work will require sloping the pit walls and ensuring that contaminated drainage cannot flow out the southeast end of the pit. A determination will also have to be made as to what is to be done with the lime plant sludge that is currently being placed on the floor of the open pit.
- recapping the main shaft – there is already a concrete cap stopping the main shaft. However, it will have to be determined whether that cap meets the requirements of the current Mine Rehabilitation Code of Ontario, and whether there are any other mine openings on the site that require either capping or backfilling.
- dealing with the thin crown pillar – there is reportedly a very thin crown pillar over the underground mine workings. A geotechnical study will need to be conducted to determine the location and extent of the crown pillar, and appropriate rehabilitation measures will need to be designed
- the foundations remaining on the site – there are a number of old concrete foundations on the site that should be removed to grade or below.

Consideration will also need to be given as to whether the mine site area is to be covered with soil, or some other growth medium, so that the area can be revegetated.

Post-Phase "E": The Clean-up of the Rehabilitated Kam Kotia Mine Site

While this will be a very minor project, there is a fair amount of garbage and construction litter on the site that should be removed once all of the other work has been completed.

Post-Phase "E": The Continuing Operation of the Lime Plant

As stated previously, the SENES plan indicates that the Kam Kotia lime plant will need to operate for approximately fifty years if all of the entire five-phased rehabilitation plan is properly completed on the site, and will have to run forever if all rehabilitation is not fully completed.

MNDM currently has a five-year contract for the operation and maintenance of the lime plant, which expires on March 31, 2008. It is expected that the next five-year contract for the operation and maintenance of the lime plant will be advertised and awarded by the expiry of the current contract.

The current lime plant operator has successfully conducted a number of modifications and efficiency up-grades during the years that they have been responsible for the plant. The result is that the plant operates at a higher than originally designed capacity and also has much less down-time than occurred during the first years of operation.

The current operator is also studying whether changes to the MOE-approved Certificate of Approval (C. of A.) are feasible in order to direct the lime plant discharge southwards towards the Little Kamiskotia River rather than continuing to discharge onto the NIT area where it is recontaminated.

Currently the operation and maintenance costs for the lime plant are approximately $400,000 to $420,000 per year. MNDM also pays $70,000 to $80,000 per year directly to Ontario Hydro One as hydro-electric costs.

The Cost of Rehabilitation

As stated previously, SENES predicted that the cost for the total rehabilitation of the Kam Kotia site was approximately $41 million, including a 30% contingency. However, MNDM will have expended almost $51 million on the site upon the completion of the current contract for the construction of the remainder

of the NIT cover. And it is now estimated that the total rehabilitation costs for the site, once all of the remaining work has been conducted, and not including any lime plant operation costs, will be greater than $55 million. Table 2 compares the predicted project costs to the actual costs that MNDM has paid for each rehabilitation project.

Table 2: Projected costs for each phase of rehabilitation at the Kam Kotia Mine site

Phase	**Projected Costs *** **($ millions)**	**Actual Costs **** **($ millions)**
A	$4.485	$10.626
B	$3.285	$3.530
C	$8.190	$7.090
D	$3.372	Not yet completed.
E (NIT Cover)	$11.402	$15.960
E (Physical Hazards)		Not yet completed.
NUT Area Water Treatment	Not planned.	$11.265
Total Cost to Rehabilitate the Kam Kotia Mine Site	**$30.734**	**$48.471 (to date)**
		$55.400 (total predicted)
Lime Plant Costs (e.g. operated - 50 years)	$10.062	$2.300 (to date)
		$25.000 (Estimated at $0.500 per year)

* Projected costs include 30% contingency.

** Actual costs may include Engineering/Design and/or Project Management Costs

Literature Cited

SENES Consultants Limited, Lakefield Research Limited, ESG International, Denison Environmental Services; August 2000; “Final Report – Kam Kotia Mine Property Rehabilitation Study – Phase 1”.

Web Pages

Ontario’s Abandoned Mines Rehabilitation Program - http://www.mndm.gov.on.ca/mndm/mines/mg/abanmin/abanpro2_e.asp

For additional information or clarifications please contact Chris Hamblin at:
chris.hamblin@ontario.ca